Simulation of Steam Engine with Aspen Plus® V8.0

1. Lesson Objectives

- Learn how to simulate a steam engine with Aspen Plus
- Learn how to specify pumps, heaters, and turbines

2. Prerequisites

- Aspen Plus V8.0
- Introductory thermodynamics

3. Background

A steam engine consists of the following steps:

- Water is pumped into a boiler using a pump.
- Water is vaporized in a boiler and becomes high temperature and pressure steam.
- Steam flows through a turbine and does work. The pressure and temperature go down during this step. The steam is also partially condensed.
- The steam is further cooled to be condensed completely. Then, it is fed to the pump mentioned in the first step to be re-used.

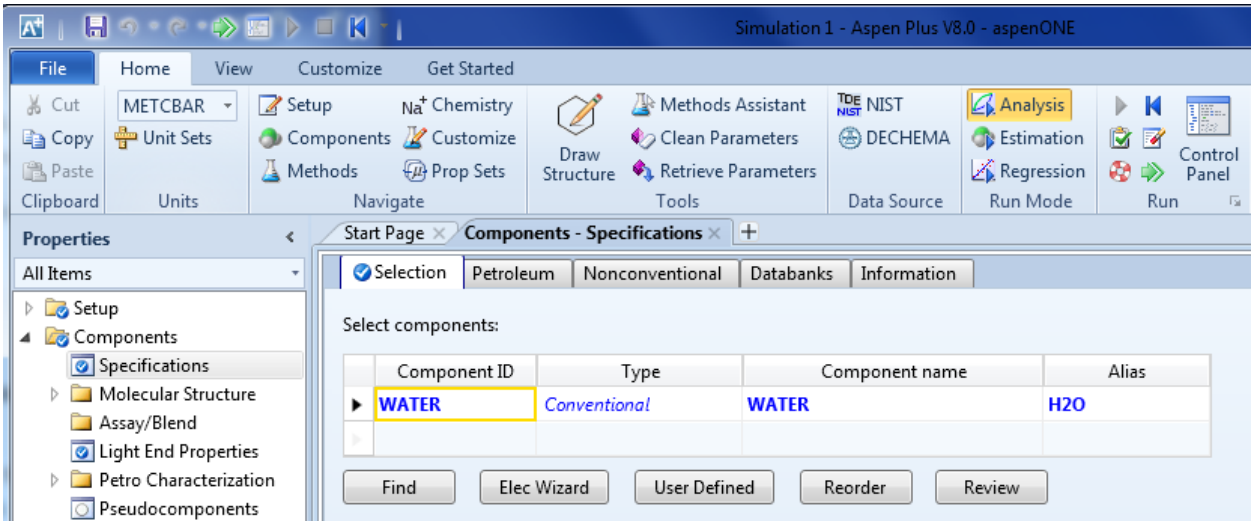
Also, we will look at the plot of vapor pressure versus temperature using pure property analysis in Aspen Plus to help us understand which phase water should be in for a given temperature and pressure.

The examples presented are solely intended to illustrate specific concepts and principles. They may not reflect an industrial application or real situation.

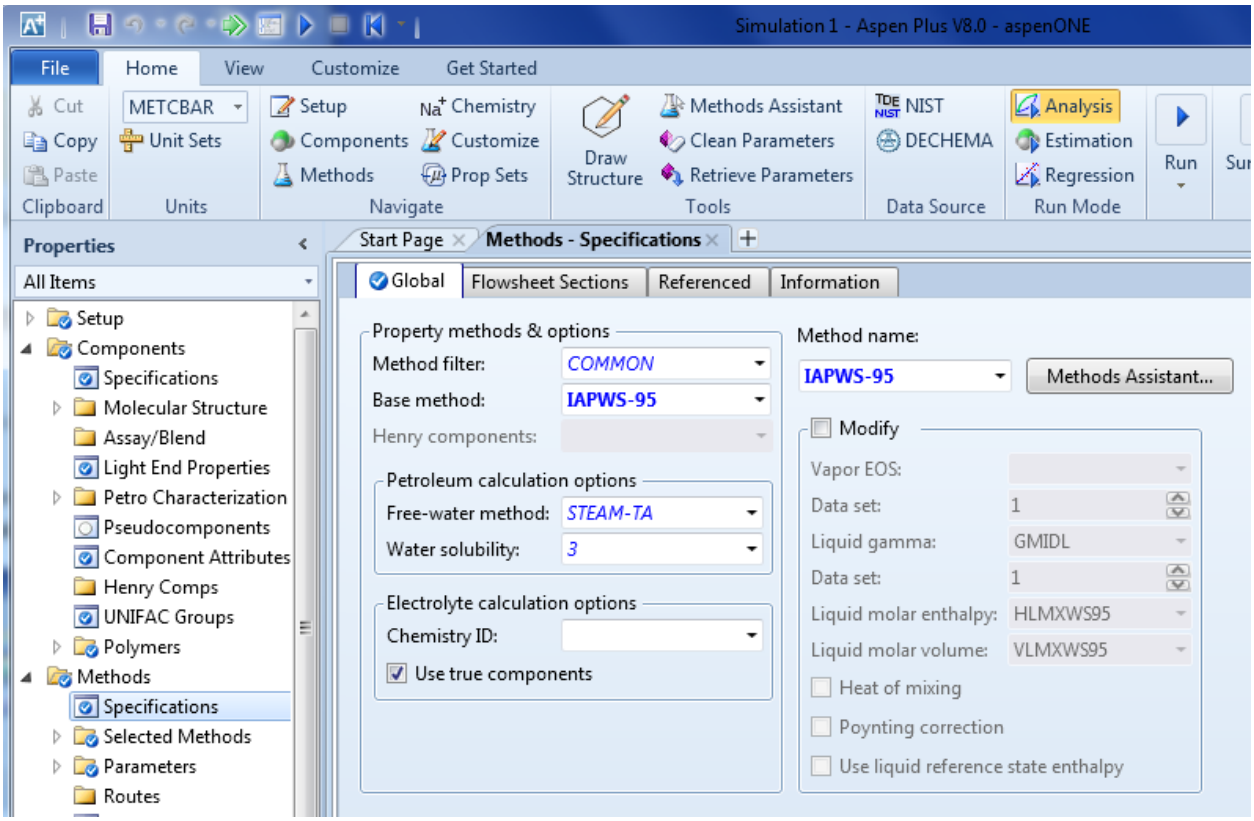
4. Aspen Plus Solution

If you are unfamiliar with how to start Aspen Plus, select components, define methods, or construct a flowsheet, consult **Get Started Guide for New Users of Aspen Plus.pdf** for instructions.

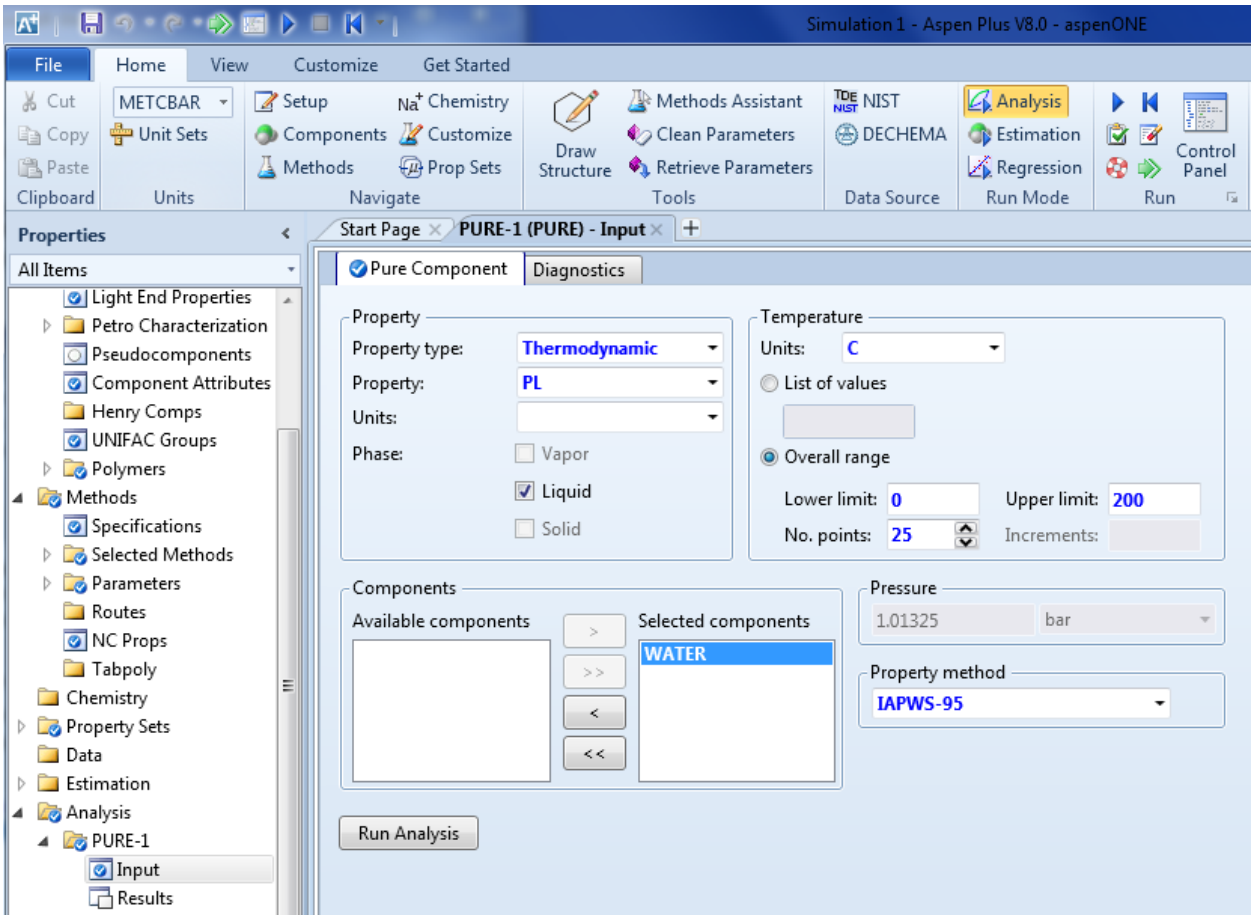
4.01. Create a new simulation in Aspen Plus using the **Blank Simulation** template. The **Components | Specification | Selection** sheet is displayed. Enter **WATER** for **Component ID**.



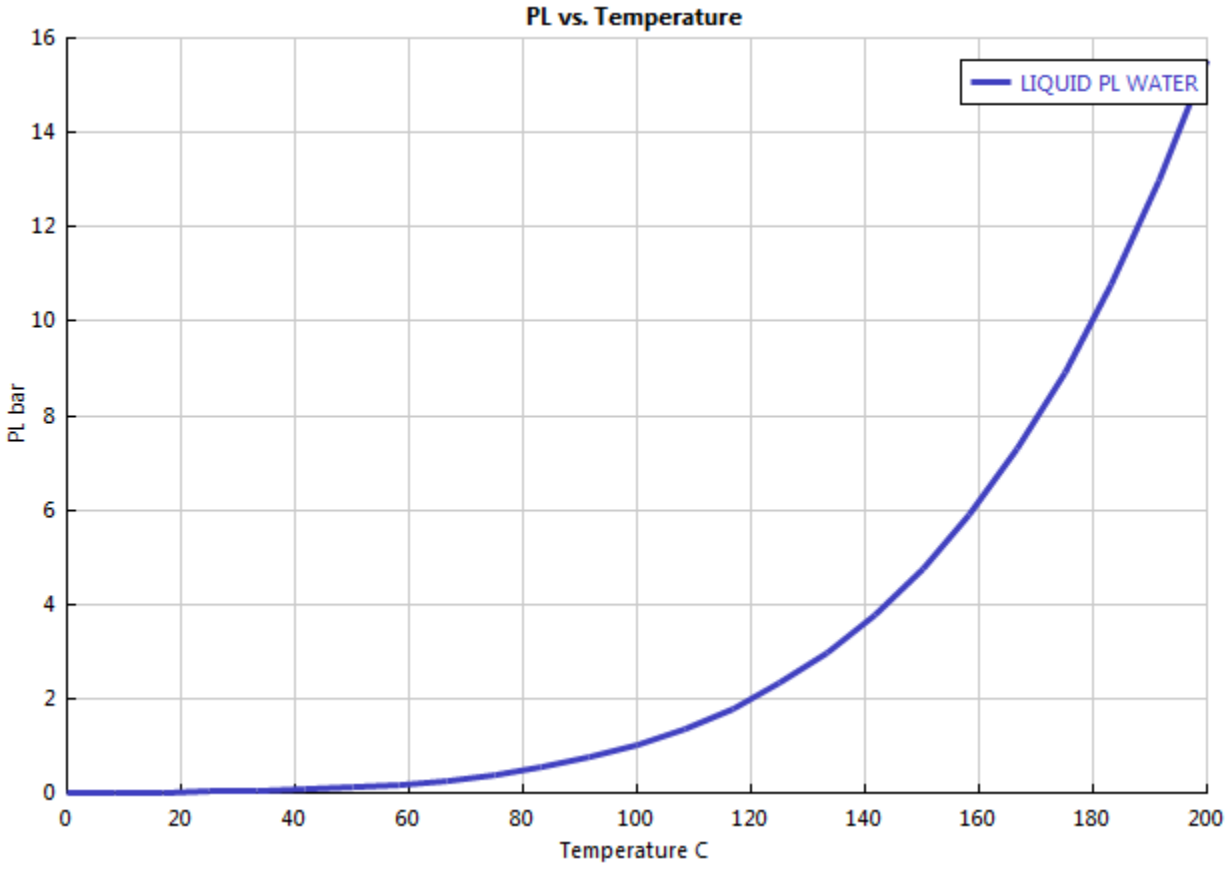
4.02. Since water is the only component in this tutorial, **Method assistant** should recommend IAPWS-95. Go to the **Methods | Specifications | Global** sheet and select **IAPWS-95** for **Base method**.



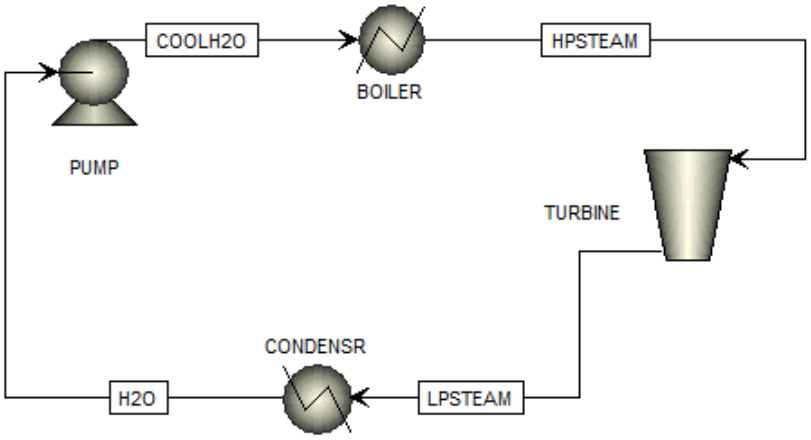
4.03. Click the **Analysis | Pure** button from the **Home** tab of the ribbon to create a new pure property analysis. Select **PL** for **Property** and enter **200** for **Upper limit** and **25** for **No. points**. In the **Components** form, move **WATER** into the **Selected components** area.

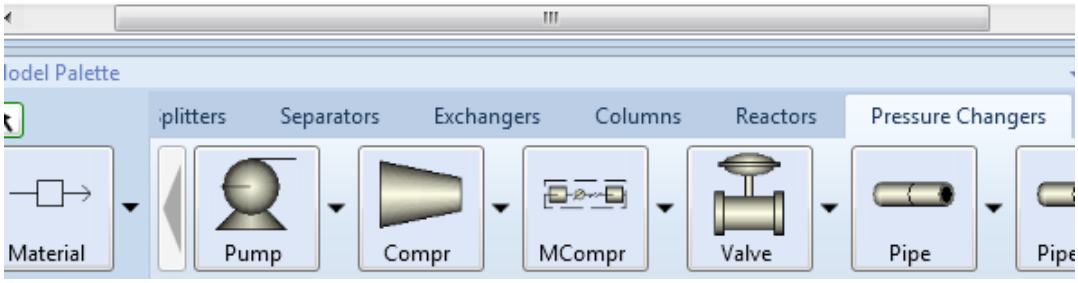


4.04. Select the **Run analysis** button to generate the property plot for water. This plot shows which phase **WATER** should be in for a given temperature and pressure.

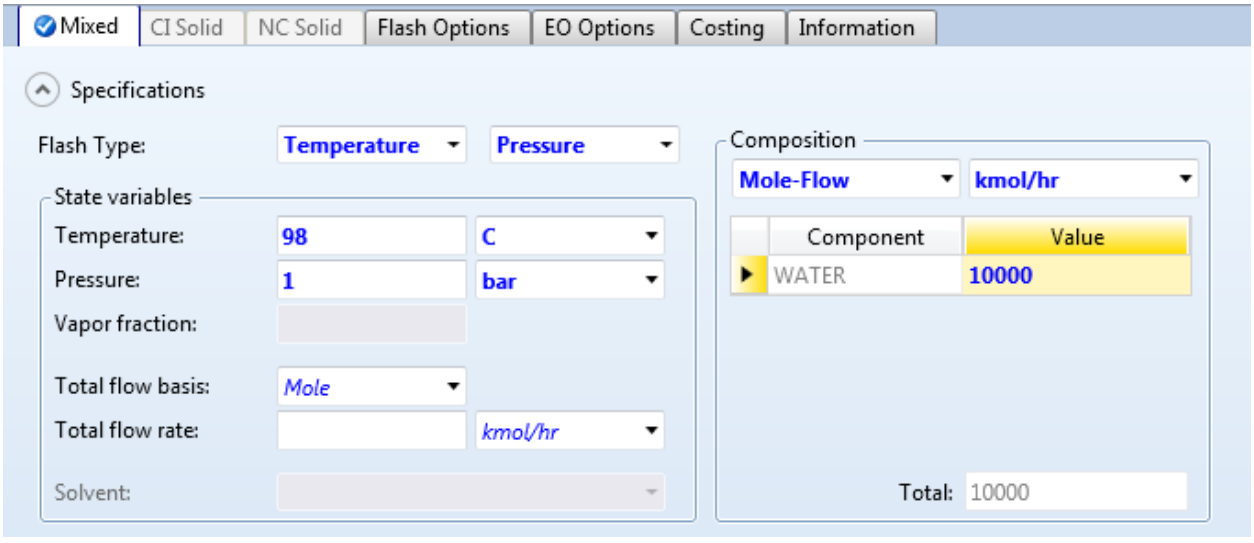


4.05. Enter the simulation environment. Add two **Heaters**, a **Pump** and a **Compressor** as shown in the flowsheet. Connect the four units with **Material Streams**. Name the streams as in the screenshot provided below. Note that the **Compr** model can be used to model a Turbine.

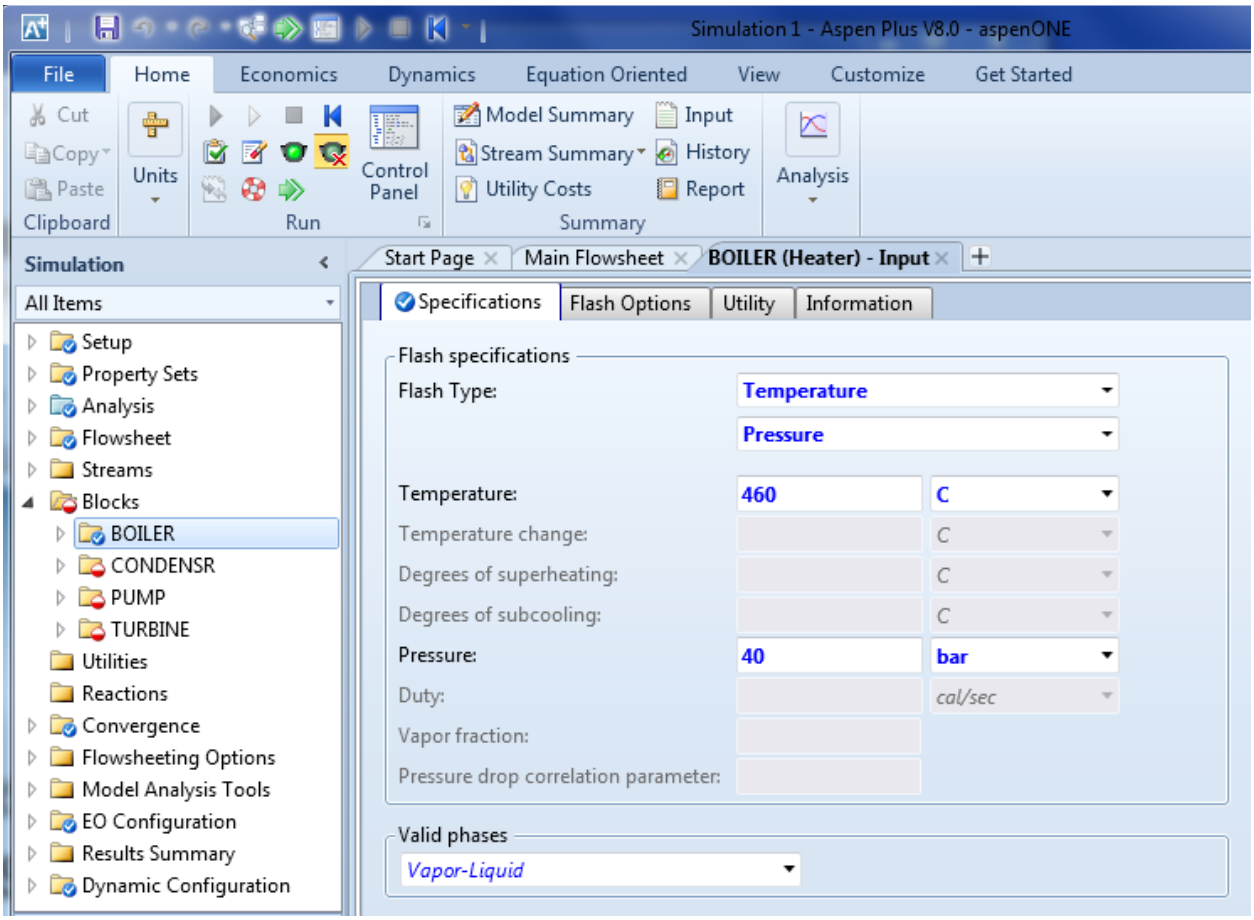




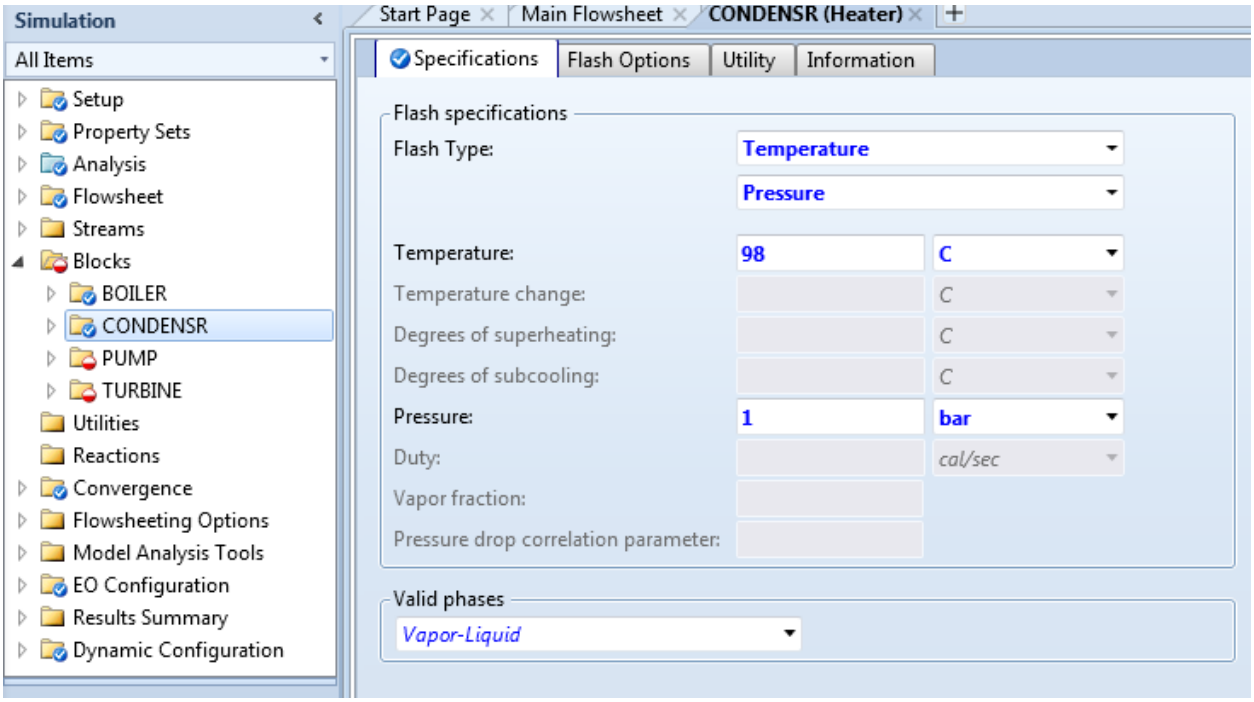
4.06. Go to the **Streams | H2O | Input | Mixed** sheet. Enter **98** and **C** for **Temperature**, **1 bar** for **Pressure**, and select **Mass-Flow** and **kg/hr** from the drop-down lists in the **Composition** frame. Enter **10000** for **WATER** value field to specify the flow rate.



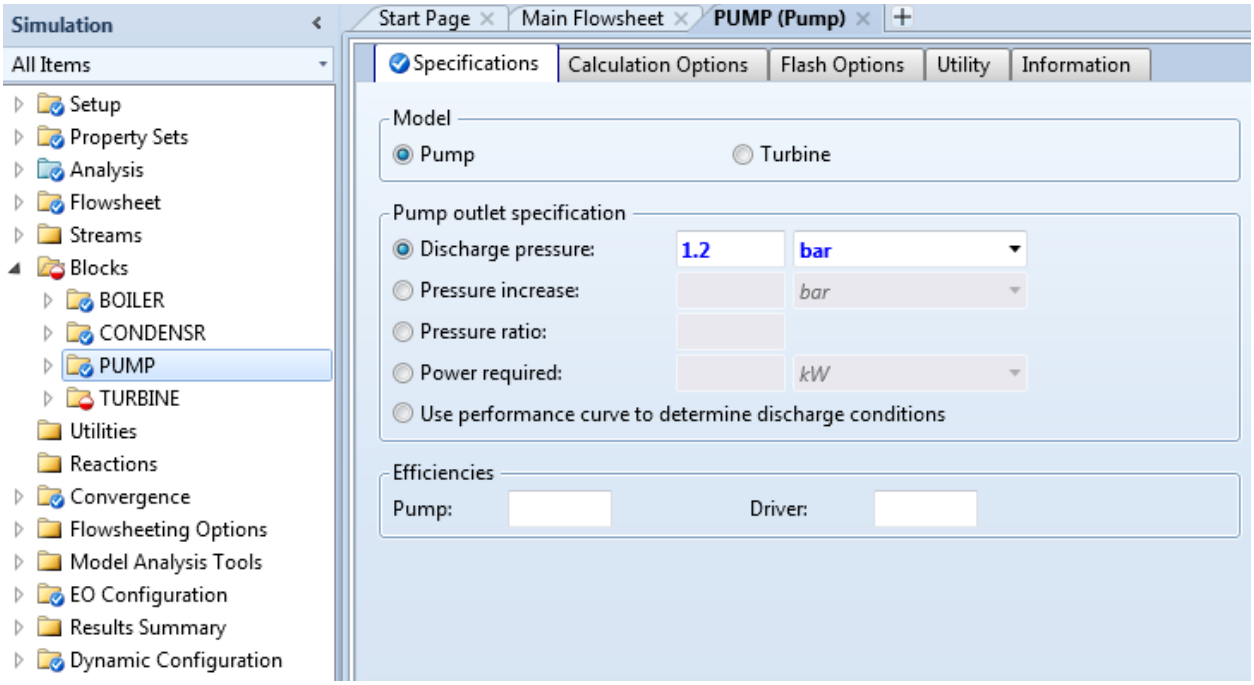
4.07. Go to the **Blocks | BOILER | Input | Specifications** sheet. Enter **460** and **C** for **Temperature** and **40 bar** for **Pressure**.



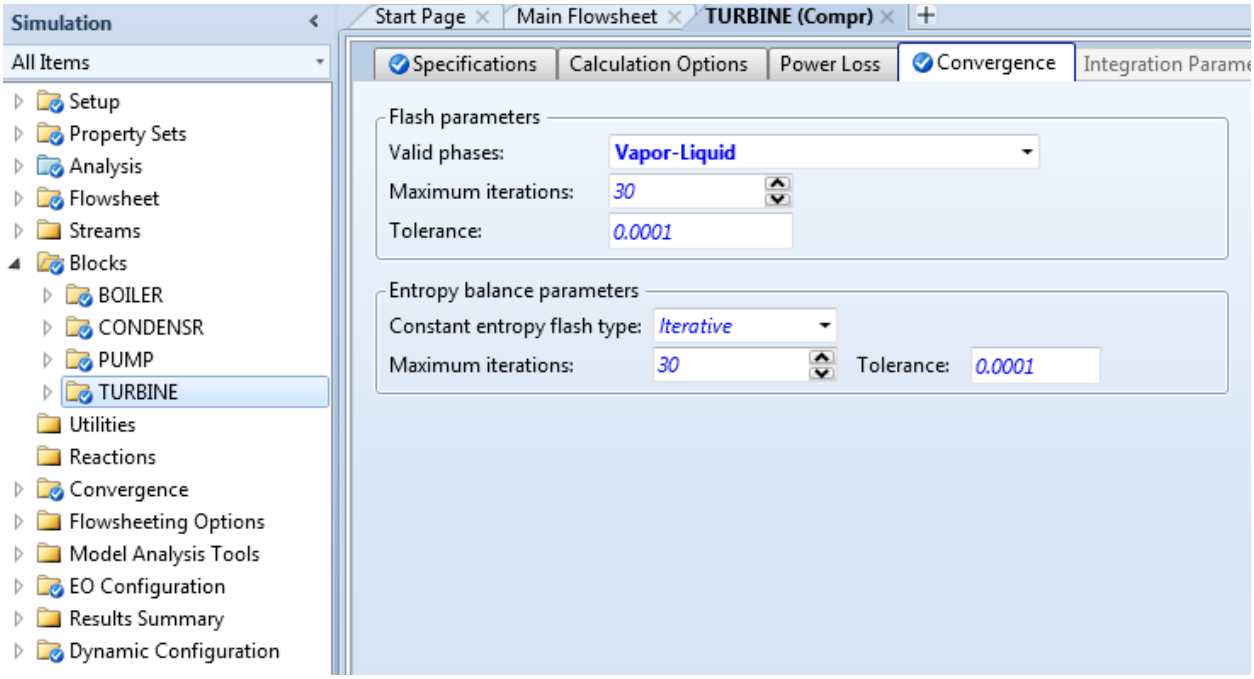
4.08. Go to the **Blocks | CONDENSR | Input | Specifications** sheet. Enter **98** and **C** for **Temperature** and **1** and **bar** for **Pressure**.



4.09. Go to the **Blocks | PUMP | Setup | Specifications** sheet. Select the radio button for **Discharge pressure** and enter **1.2** and select **bar**.



4.10. Go to the **Blocks | TURBINE | Setup | Specifications** sheet. Select the **Turbine** radio button, and select the **Discharge pressure** radio button. Enter **1** and select **bar** for **Discharge Pressure**. Go to the **Convergence** sheet and select **Vapor-Liquid** from the drop-down list for **Valid phases** (see screenshot below).



4.11. Click the **Run | Run** button under the **Home** tab of the ribbon (or press **F5**) to run the simulation. Navigate to the **Results Summary | Streams | Material** sheet. The information of the streams in the steam engine can be found. The vapor fraction and liquid fraction of each stream can be observed. The stream conditions can also be confirmed with the plot generated in step 4.04. For instance, stream **COOLH2O** is a subcooled liquid according to the plot from step 4.04, yielding a liquid fraction of 1.

Material | Heat | Load | Work | Vol.% Curves | Wt. % Curves | Petro. Curves | Poly. Curves | Solids

Display: All streams Format: FULL Stream Table Copy All

	COOLH2O	H2O	HPSTEAM	LPSTEAM
Substream: MIXED				
Mole Flow kmol/hr				
WATER	555.084	555.084	555.084	555.084
Total Flow kmol/hr	555.084	555.084	555.084	555.084
Total Flow kg/hr	10000	10000	10000	10000
Total Flow l/min	173.651	173.651	13556.1	316496
Temperature C	98.008	98	460	142.081
Pressure bar	1.2	1	40	1
Vapor Frac	0	0	1	1
Liquid Frac	1	1	0	0
Solid Frac	0	0	0	0
Enthalpy cal/mol	-66952.4	-66952.6	-54287.1	-56840.3
Enthalpy cal/gm	-3716.42	-3716.43	-3013.39	-3155.12
Enthalpy cal/sec	-1.0323e+07	-1.0323e+07	-8.3705e+06	-8.7642e+06
Entropy cal/mol-K	-35.0221	-35.0224	-10.5575	-7.94596
Entropy cal/gm-K	-1.94402	-1.94404	-0.586029	-0.441068
Density mol/cc	0.053276	0.0532758	0.000682453	2.92307e-05
Density gm/cc	0.959782	0.959779	0.0122945	0.000526599
Average MW	18.0153	18.0153	18.0153	18.0153
Liq Vol 60F l/min	166.988	166.988	166.988	166.988

4.12. Note that there are two warnings regarding lack of feed stream and outlet stream for this flowsheet. These appear because water circulates within the flowsheet. Therefore, the warnings can be ignored.

5. Conclusions

The steam engine system can be simulated using Aspen Plus. The user can develop this flowsheet further by adding heat streams and work streams. By selecting and clicking the **Heat Stream** or **Work Stream** icon, the user can determine where heat streams and work streams can be added to the flowsheet. The pure property analysis can help us to validate the results of the simulation via checking the stream conditions.

6. Copyright